The University of Pittsburgh Involvement with the Grid Technologies Collaborative

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IEEE Standard 1547

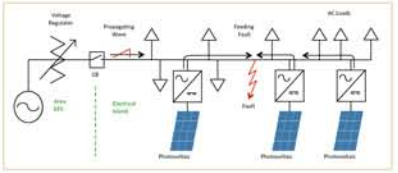
- Description of IEEE 1547
  - *IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems.*
  - Purpose: This document provides a uniform standard for interconnection of distributed resources with electric power systems. It provides requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection.
  - Anti-islanding: Requires that upon detection of an electrical islanding condition, all distributed resources are disconnected from the electric power grid within 2 seconds.

Shortcomings of IEEE 1547

- Detection of an island becomes less reliable as the total capacity of distributed generation (DG) increases relative to the load.
- Electric utilities are using accepted and understood methods to analyze DG interconnections, but these do not cover situations with large amounts of inverter-based DG connected to feeders.

System Transient Events Not Considered By Standard

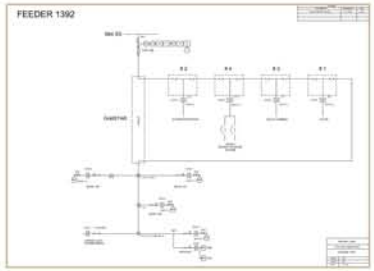
- During 2 Second Interval: Transient overvoltages during the specified 2 second interval can be damaging due to increased DG. The damaging transient results from grid disconnection (breaker opening) leaving DG and loads in islanded state resulting in excess DG compared to load within the islanded circuit feeding the disturbance.
- After 2 Second Interval: Disconnection of increased amounts of parallel connected DG on an electrically islanded condition causes a transient detrimental to system equipment.



- Testing inverters one at a time (UL standard 1741-2005).
  - National labs declare that further evaluation should be done to develop standard procedures for the condition of multiple inverters of different sizes and types connected to the same electrical island.

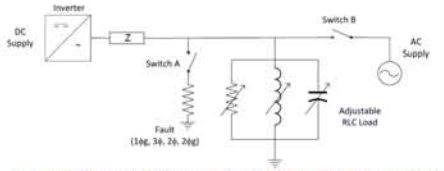
Task 1: Modeling of the Navy Yard

- The Navy Yard
  - The GTC program has made plans to utilize the Navy Yard, affiliated with Penn State University, for the purpose of testing power electronics equipment on a utility scale.
- Modeling
  - In process of obtaining parametric data.
  - Plans to use MATLAB/Simulink and PSCAD environments.
  - Deliverable: Model development of Navy Yard test facility in MATLAB/Simulink and PSCAD for future simulation verification of products built within the GTC program.



Task 2: Inverter Modeling and Testing

- Modeling and Testing
  - Perform open-circuit and short-circuit tests on inverters and verify the model performance against the experimental transient voltages and currents. This may require collaboration with the inverter vendor to improve the existing model so that it adequately reproduces the test results.



Configuration for Inverter Short-Circuit Tests (Switch A open-close, Switch B close-open) and Open-Circuit Tests (Switch B close-open, Switch A stays open)

- Inverter: Fronius IG Plus 10.0-1
  - Output: 10 kW single phase
  - Recommended PV-power: 8.5-11.5 kW
  - MPPT-voltage range: 230-500 V
  - Max input voltage range: 600 V
  - Nominal AC output voltage: 208/240/277V
  - Total harmonic distortion: < 3%
  - Islanding protection: Internal, in accordance with UL 1741-2005, IEEE 1547-2003 and NEC

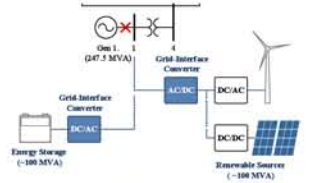
- Comparing and Selecting Lab Equipment
  - Fluke 435 Series II Power Quality and Energy Analyzer
  - Dranetz PowerXplorer PX5 Power Quality Analyzer

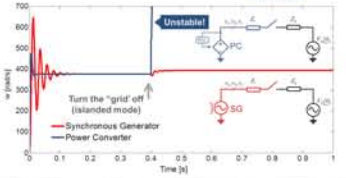
Shortfalls of IEEE 1547 Benefit the GTC Program

- Value for the GTC
  - Creating a potential hub for standard testing and certification.
    - Developing "in-house" inverter testing capability that will be helpful in developing and testing new power electronic systems before deployment in the Navy Yard.
  - Eventually Task 2 has the potential of being incorporated into standard revisions creating stronger GTC recognition at the IEEE level.

University Synergy within GTC

- Virginia Tech
  - Investigating the stability of parallel connected inverters within the WECC 9-Bus Test System





- Penn State University
  - Coordinating and supplying data for modeling the Navy Yard facility

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